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COMMITTEE ON THE PEACEFUL USES OF
OUTER SPACE

REVIEW OF NATIONAL AND INTERNATIONAL SPACE ACTIVITIES FOR THE CALENDAR YEAR 1989

Note by the Secretariat

The present document contains information provided in replies received from Member States up to 26 April 1990.

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BULGARIA

[Original: Russian]

In the People's Republic of Bulgaria, space research was carried out in the following main areas:

- Space physics;
- Remote sensing of the Earth from outer space;
- Space biology and medicine;
- Space communications;
- Space meteorology.

SPACE PHYSICS

Experiments and instruments were developed for the following projects under the Intercosmos programme:

- Aktivny, for studying processes and phenomena in the ionosphere and in magnetospheric plasma under the active effects of electromagnetic waves and flows and neutral particles;
- Apeks, for studying the interaction of ionospheric and magnetospheric plasma with streams of accelerated charged particles, and for studying other ionospheric and magnetospheric processes and phenomena;
- Interbol, for studying physical processes in the transfer of energy from the solar wind in the magnetosphere, and its buildup and subsequent dispersion in auroral regions;
- Granat, for studying X-ray and gamma-ray sources in space jointly with the USSR, France and Denmark;
- Spektr-Roentgen-Gamma, for which the technical tasks, outline drawings and installation drawings for star sensors were co-ordinated;
- Mars-94, on which work was begun;
- Shipka, under which the results of research in space-materials science were processed, including those derived from the Kliment-Rubidy, Struktura and Voal experiments. Under the Voal experiment, carried out under microgravity on board the Mir orbital station, much better results were obtained with regard to the structures of tungsten-aluminium.

In September 1989 in Primorsko, Bulgaria, the second school for young scientists and space physicists was founded with a view to raising the scientific level of space research, familiarizing the students with achievements in adjacent

fields and establishing closer contacts between young scientists and leading specialists in various countries.

REMOTE SENSING

Multichannel images received by Fregat under the Phobos project underwent preliminary processing and interpretation.

A three-dimensional model of the Martian moon Phobos was made. The moon's colour characteristics and the colour co-ordinates in a series of control points were determined.

Theoretical and experimental research using spectrocolorimetric systems was carried out. The Spektr-256 equipment continues to be improved. A number of results were received jointly with Cuban scientists. Work was done on the Priroda project, and a scanning bipolarized radiometric system was developed. Work was also done on the project entitled "Internal reservoirs" (in the territory of Bulgaria and the USSR), the Geologia project (concerning geology) and the Susha ("dry land") project (concerning agricultural areas).

SPACE BIOLOGY AND MEDICINE

The results received from the Shipka project were processed. Markedly better results were obtained from various forms of psycho-physiological research on cosmonauts. Work on the terrestrial application of original apparatus was begun. This includes Pleven-87, for research on the work capability of operators; Son-3, for recording sleep parameters; Lyulin, a dosimeter-radiometer; and Zora, a system for collecting and processing medical and biological research data.

In May 1989, the twenty-second session of the Intercosmos working group on space biology and medicine was held in Bulgaria.

Joint research (USSR, Czechoslovakia, Hungary) was conducted on a new Bulgarian radiation protector aimed at enhancing radiation safety during space flight; and a preparation for treating radiation exposure of the skin was developed and tested.

SPACE COMMUNICATIONS

Work was carried out in the following fields:

- Exploitation of new frequency bands, and the construction of experimental systems of satellite communications in the 10-30 GHz bands;

- Receivers were built for television signals in the 4 and 12 GHz bands;

- The principles of effective use of the geostationary orbit were developed, as was the sharing of frequencies by satellites and ground stations;

- Systems of satellite television broadcasting in the 12 GHz band were developed and readied for service.

SPACE METEOROLOGY

Work was carried out with a view to improving the methodology for vertical correlation of variations in geopotential and temperature in the stratosphere.

A method was developed for forecasting the formation, evolution and movement of small African depressions with the aid of Meteosat images. Research was done on the large-scale characteristics of cloud cover over Europe which preceded sharp drops in temperature over Bulgarian territory.

Bulgarian delegations of scientists and specialists participated in the 40th Congress of the International Astronautical Federation (IAF) in Malaga, Spain, and in the international Phobos-Mars seminar under the auspices of the Committee on Space Research (COSPAR) in Paris in October 1989.

Bulgaria is elaborating a national space programme which provides for the country's participation in large space projects on the basis of broad scientific co-operation with other countries in the peaceful uses of outer space.

GERMAN DEMOCRATIC REPUBLIC

[Original: Russian]

In 1989, once again, work in the German Democratic Republic on the exploration and use of outer space was carried out on the basis of the 1967 Outer Space Treaty and the 1976 multilateral Agreement on Co-operation in the Peaceful Exploration and Use of Outer Space (Intercosmos Agreement).

Co-operation progressed in accordance with established plans in the main fields covered by the Intercosmos programme: space physics, including space-materials science; remote sensing of the Earth; space meteorology; space biology and medicine; and space communications.

The main features of the work done and results achieved are described below.

1. The twelfth session of the conference of heads of national co-ordination bodies of the countries participating in the Intercosmos programme was held between 23 and 28 October 1989 in Neubrandenburg.

The following broad topics were discussed:

- The activities of the standing groups during the period 1988-1989;

- Measures to promote more effective participation of the Socialist Republic of Viet Nam, the Republic of Cuba and the Mongolian People's Republic in the Intercosmos programme;

- Research into the possibility of transmitting the results of scientific space research by computer over satellite communication channels;

- Participation by the member countries of Intercosmos in the 41st Congress of the International Astronautical Federation (IAF) in Dresden in 1990;

- Preparations for participation by the Intercosmos programme in the International Space Year, to be commemorated in 1992.

2. Video information received by the Phobos probes was processed. The processed data are available in the form of a catalogue. The data obtained from an experiment using magnetometers (German Democratic Republic, Austria, USSR) on board the Phobos-2 probe provided additional knowledge about the magnetic characteristics of Mars and the solar-wind flow, as well as indications of the planet's rotating magnetic field.

3. In order to interpret plasma measurements made during the Vega/Giotto and Phobos missions, calculations were made on the basis of multi-fluid equations. This enabled scientists to develop a new comet model which, instead of being based on the frontal shock-wave near the resonance points (ion-acoustic waves, or Alfvén resonance), is based on the non-steady-state flow field. This makes it possible to interpret the plasma boundary layers that were observed.

The preliminary results of the model of the Martian magnetosphere lead to the conclusion that the magnetopause identified by plasma-measuring instruments (FGMM-1, Aspera, Taus) can be explained by analogy with the cometopause.

4. The Intercosmos-24 satellite (carrying the Aktivny experiment), launched on 27 September 1989, has on board Langmuir probes developed in the German Democratic Republic. Data received thus far from the probes demonstrate the operational capability of the instrument. The data are currently being processed for scientific interpretation.

5. Co-operation with Cuba and Viet Nam has continued successfully on the basis of division of labour in the field of ionospheric physics using two-channel polarimeters manufactured in the German Democratic Republic for measuring the Faraday rotation of radio signals from geostationary satellites. By using these measurements, it is possible to determine the total number of electrons in the ionosphere. The principal task in 1989 involved research on:

- Ionospheric storms in low and middle latitudes;

- The effect of the nightside winter anomaly;

- The behaviour of the ionosphere near the geomagnetic equator;

- The interaction of the ionosphere and the plasmosphere based on the night-time increase in the total number of electrons.

6. The Central Geophysics Institute participates, through the Potsdam stations and to some extent through the station at Santiago, Cuba, in the laser programme of

the International Earth Rotation Service. The range to the LAGEOS satellite was measured with an accuracy of +/- 10-20 cm. The laser system was improved, and a new-generation laser system is also being developed which will ensure subdecimeter accuracy. Using the measurements of the range to the LAGEOS satellite obtained at stations around the world together with the Potsdam-5 software package, it was possible to calculate certain geodesic and geodynamic parameters with a high degree of accuracy. The co-ordinates of the stations and of the pole were determined with an accuracy of several centimetres, and the variations in the co-ordinates of the stations helped in developing a tectonic-plate model. Determination of the rotation parameters made it possible to develop a very accurate reference system.

7. In 1989 four Cuban specialists completed many weeks' training in the German Democratic Republic. The purpose was the joint processing and interpretation of data from the multi-stage experiment Caribe-Intercosmos (conducted in March/April 1988 in Cuba). The results of the research, designed to assist in evaluating the bioproductivity of crops, measuring the concentration of aerosols in the atmosphere and mapping the continental shelf, were presented at a seminar held in Havana in early 1990. The data obtained with the aid of spectrometers as part of the Caribe-Intercosmos experiment from the Mir station, from an aircraft (AN-30) and on the ground are being used to test an algorithm for correcting the effect of the atmosphere on remote-sensing data obtained with MKS-M equipment.

8. The Second United Nations Training Course on Remote Sensing Applications to Geological Sciences was held at the Central Geophysics Institute from 5 to 22 October 1989, with the participation of 17 specialists from 15 countries.

9. In November 1989 the scientific module D was launched in the USSR and docked with the Mir station. The module, made in the German Democratic Republic, is carrying an MKF-6MA multispectral camera (Carl Zeiss Jena) and an MKS-M2 multichannel spectrometer of the Space Research Institute of the Academy of Sciences of the German Democratic Republic. The results of the measurements made with these instruments are expected in the course of 1990.

10. In October 1989 the Zingst station began regular launching of weather rockets to obtain temperature and wind data at altitudes of up to 75 km. (Soviet MMR-06M weather rockets are normally launched once a week, on Wednesdays.) This station supplements a meteorological sounding network (USSR, Mongolia, Bulgaria, German Democratic Republic) developed in the context of co-operation under the Intercosmos programme. A system developed by the Meteorological Service of the German Democratic Republic for the reception and interactive processing of digital video information from weather satellites to be used for weather analysis and forecasting was put into operation. A variant of this system was set up in the Democratic Republic of Korea.

11. Scientists continued research on processes occurring in the middle atmosphere and lower ionosphere, using rocket-probe and remote measurements of the altitude of phases, absorption and drift, and also measurements of partial reflection. This research involves empirical modelling of meteorological parameters in that range of altitudes and the study of seasonal changes in circulation, atmospheric wave processes, and interactions between high and low atmospheric layers.

An important result of the research was the verification of long-term, systematic cooling of the middle atmosphere during the period 1965-1988.

12. In the processing of satellite measurements of radiation and rocket data, researchers studied the speed of cooling in the middle atmosphere brought about by its CO_2 content.

13. On board the Mir orbital station, the KP-01 instrument package was successfully used for measuring the partial oxygen pressure in the capillary blood of cosmonauts. This research is being repeated in early 1990.

14. Scientists of the German Democratic Republic took part in experiments carried by the Cosmos-2044 biosatellite (14-29 September 1989). The experiments used:

- A miniature telemetric system for continuous recording of the temperature of the body before, during and after space flight lasting 14 days. The data obtained is being used to analyse biorhythmic processes for evaluating adaptation to weightlessness;

- Magnetic variable-resistance transducers for evaluating the function of balance in monkeys during space flight.

15. A psycho-physiological functions test was developed and tried out with a view to assessing cosmonauts' concentration, endurance and reactivity, as well as their rate of progress and decision-making ability for purposes of selection.

16. In the field of radiation protection during space flight, scientists in the German Democratic Republic continued dosimetric research on board spacecraft. Processing of the results using solid-state detectors installed on board various Cosmos-series satellites yielded information on the type and angular distribution of the low-energy component of cosmic-ray particles. The gradient of the dose resulting from such particles hitting the outside of the spacecraft was determined. Scientists continued their study of the neutron component as part of their dosimetric research carried out on board the Cosmos-2044 biosatellite.

17. Work continued in the German Democratic Republic for the purpose of exploiting frequency bands up to 30 GHz for satellite communication systems. Assemblies were developed for studying wave propagation for a satellite transmitter and a corresponding ground reception station operating in the 11, 20 and 30 GHz frequency bands.

18. The German Democratic Republic is a member of the international organizations Intersputnik and Inmarsat and uses the existing systems for transmitting various types of information.

HUNGARY*

[Original: English]

INTRODUCTION

1. In the absence of technological know-how and financial resources, Hungary is not in a position to develop and carry out an independent space programme. Our work in this field consists of wide-ranging, solidly based international co-operation. Our most important partner is the Soviet Union and our joint research is carried on primarily within the framework of the Intercosmos programme in the following areas:

- Space physics;
- Space biology and medicine;
- Satellite-assisted exploration of natural resources (remote sensing);
- Satellite meteorology;
- Space communication.

2. The results of this co-operative effort are utilized in several fields for a variety of purposes. Hungarian scientists are afforded the chance to take part in unique experiments: they regularly obtain new data and up-to-date information about space, the Earth and other celestial bodies, and about the effects of weightlessness. Some of these data, especially those concerning meteorology and the exploration of natural resources, are already being put to practical use. Hungarian engineers take part in the development of measurement techniques and in the construction of scientific instruments applicable not only in space research, but also in industry, medicine and education.

I. SPACE RESEARCH

3. Particular emphasis is given to the following space activities:

A. Space physics

4. The research started during the earlier years in the field of magnetosphere and ionosphere physics has been continued. In addition to theoretical studies, onboard instruments have been and are being built for the Soviet projects "Active" and "Apeks" for the exploration of the terrestrial environment.

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* This report has been compiled by the secretariat of the Intercosmos Council of the Hungarian Academy of Sciences (H 1369, Budapest, P.O.B. 315, Hungary).

5. During 1989 Hungarian scientists participated in research in the fields of cometary physics and interplanetary space.

6. A new activity started with the Phobos missions launched by the USSR in July 1988. Among the instruments, designed for plasma measurement, was the ESTER measuring complex, which consisted of three particle instruments. The Low Energy Telescope (LET) detected the flux, spectra and elemental composition of nuclei up to iron in the energy range of 1 MeV/n to 75 MeV/n. The SLED detector system monitored electron and ion fluxes in selected channels within an energy range spanning several tens of keV to a few MeV.

7. The HARP hyperbolic electrostatic analyser served for measuring the energy spectra and angular distribution of electrons and ions with energies below 1 keV. The instrument is an essentially improved version of a detector developed for terrestrial ionospheric research by the University of Michigan and launched by rocket several times. In the work of development engineers of the University of Michigan and CRIP (Central Research Institute for Physics, Budapest) were involved together with researchers of the IKI Moscow. The instrument was built in the CRIP, the calibration was performed by Hungarian engineers in the United States (Ann Arbor and Huntsville).

8. The apparatus has been working during the whole mission apart from shorter gaps; however, the most interesting measurements were made in the environment of Mars. The crossing of the bow shock and the suprathermal particles of the magnetosheath were observed both in the electron and ion spectrum. The most interesting result is the discovery of the hot electron component of the tail, a region not yet explored by earlier spacecraft.

9. On 28 September 1989 the Intercosmos-24 satellite carrying the instrument of project Active was successfully launched. The global aim of the project is to investigate the propagation of VLF electromagnetic waves ($\sim$30 Hz - 30 kHz) in the upper atmosphere and their interaction with particles of the radiation belts.

10. Large-scale international co-operation emerged with the participation of institutions from the United States, Canada, Japan, Finland, Brazil and the United Kingdom. The telemetry broadcasts of the satellite are also taken by a ground station of NASA.

11. Hungary significantly contributes to the Active project. The central data acquisition system and the SAS (Signal Analyzer and Sampler) instrument was built by Hungarian engineers. The scientific co-ordination, the processing and evaluation of the data of the SAS experiment is made by Hungarian scientists. The instrument takes digital samples of five field components (three magnetic and two electric) of the electromagnetic waves in a frequency band 900 Hz wide and transmits it to the Earth via its 460.4 MHz own transmitter at a speed of 80 kbit/s. The median frequency of the band can be varied between 500 Hz and 21.5 kHz.

12. The primary goal of the SAS experiment is to determine with high accuracy the direction of propagation and fine structure of VLF waves. The instrument is

working properly and provides valuable data. So far during 11 seances about 17 Mbyte information has been gathered.

B. Space biology and medicine

13. In the late 1960s, Hungarian physicians first joined the biomedical research activity of the Intercosmos space research co-operation. Scientific investigations were greatly stimulated by the first Soviet-Hungarian spaceflight. At present there are 13 teams of Hungarian research workers taking part in this activity and their studies range on three fields of space biomedical research, i.e. space physiology, space radiation protection and biology, and space psychology.

14. Scientific investigations in the Institute of Aviation Medicine cover all these three fields. During the past years, studies of applied physiology were focused on developing objective testing methods to assess the actual working capacity in man. The peak and the reserves of human performance are assessed in a measurement unit by continuous monitoring of the cardiovascular and the respiratory systems during treadmill exercise. Another objective testing method is the 26-hour recording of cardiac activity on a magnetic tape and the computer-assisted analysis of the data obtained. This method permits continuous monitoring of cardiac parameters even in real flight.

15. The other essential factor of the actual working capacity is mental performance. The physcho-emotional state and mental performance are investigated. The device Balaton developed by the time of the Soviet-Hungarian spaceflight is very helpful in the comprehensive assessment of the mental state. A computer program for data processing of these multiparametral psychological measurements has also been developed. Results of the experiments carried out in co-operation with the Soviet research workers may be useful in cosmonaut selection and in pre-flight, in-flight and post-flight assessment of their working capacity.

16. A method to simulate physiological effects of weightlessness has been developed in the Institute of Aviation Medicine. The main point in it is a cage limiting the movement of the animals. Using this method, the Biochemical Institute of Szent-Györgyi Albert Medical University, Institute of Physiology and Institute of Pathophysiology of the Debrecen Medical University investigated the effect of hypokinesia on the muscular system.

17. Studies of the effect of hypokinesia on the gastrointestinal tract were performed together with research workers of the Institute of Pathophysiology, Semmelweis Medical University. These experiments contribute to a better assessment of changes arising in the different organs under the effect of weightlessness.

18. Besides educational work, the interest of the research workers of the Biochemical Institute, Szent-Györgyi Albert Medical University, is focused on biological differentiation. Changes in the circulatory system and biochemical and biophysical alterations of skeletal muscles in weightlessness were studied first.

II. APPLIED SPACE RESEARCH

A. Remote sensing

19. The first phase of the development of a passive microwave instrument as well as the processing method and software aiming at the determination of soil moisture has been completed. The whole system (C and S band radiometer, onboard data collection and telemetry system, processing unit) has been tested. During the in-flight tests the system functioned properly.

20. Field tests of crop condition assessment using aerial remote-sensing methods have been completed. The introduction of the methodology into agricultural practice is in progress.

21. The development of crop mapping, crop development assessment and yield forecast method for large areas based on satellite imagery has been continued. Area estimation and yield models gave accuracies better than 90 per cent.

22. Soil mapping methodology based on colour infrared aerial photography has been improved and is being introduced into practice.

23. A study as a first step of the development of an environmental monitoring system has been completed. Within this framework the first field survey - using a multichannel imaging spectrometer - has been performed in co-operation with Moniteq of Canada.

24. Hungarian researchers participated in the work of a geologic expedition organized in the Tien-Shan mountains aiming at the survey of tectonically active areas.

25. Hungarian specialists participated in the work of the international project of elaboration of geo-information systems. The results achieved and the plans of further development - based on the ESRI ARC/INFO system - has been presented and have met the appreciation of the experts of the international project.

B. Material science in space

26. The preparation of a crystallization experiment in space has been continued. Test materials and flow charts have been prepared and heat model calculations have been done for the space oven named "Crystallisator".

27. We have been working on creating a new, multiple zone heating system that would produce crystals with computer control without moving the sample under microgravity circumstances.

C. Satellite geodesy

28. In this field Hungary's activity is concentrated on photographic, Doppler and laser observations of satellites in order to gain better data on the position of international and domestic stations as well as to increase the accuracy of the networks. Preliminary studies have been made about participation in a space VLBI experiment.

D. Satellite meteorology

29. In 1989 the analogue data from satellites Meteosat and Noaa were received. These data were used in weather analysis and forecasting as well as in weather reporting.

30. An attempt was made to explain the formation in time of the frontal cloud bands based on Hoskins' model. An attempt was also made to derive precipitable water content from vapour images from MOS-1. In connection with adaptation of TOVS Export Package, the earlier statistical technique was succeeded by the physical method. In the near future a weather prediction system incorporating satellite reports (SATEM and SATOB), developed by the Swedish Meteorological and Hydrological Institute, will be applied in routine service. Using satellite and airplane, data experiments were made to determine the areal distribution of surface temperature and evaporation of different plants and the water stress for vegetation. The water quality of Lake Balaton was studied by means of simultaneous measurements by satellite and spectrometrical instruments on the surface. The changes of the natural environment were investigated in the surroundings of hydroelectric stations planned in the region of Gabcikovo and Nagymaros.

E. Space communication

31. In the domain of space communications Hungarian activities can be classified in three categories:

(a) On the theoretical level, research has been continued on new methods of transmitting and processing various signals:

- Increasing the efficiency of signal transmission considering the statistical characteristics of speech signals and the telephone information flow of satellite channels;

- Control methods for data and telephone base bands, and for SCPC signal transmitting systems and equipment;

- Methods and systems for connecting satellite and terrestrial digital transmission channels;

(b) Practical research was carried out in the following areas:

- Corrective coding algorithms for digital radio channels;

- Simulations and implementations of digital source coding-decoding equipments for video signals;

- Wave propagation measurements in the 11/12, 18 and 22 GHz bands;

- Space-to-Earth propagation measurements in the 11/12 GHz band;

(c) Works of administration and systems technology:

- Research programme in the establishment of a direct satellite broadcasting system.

III. INTERNATIONAL CO-OPERATION

32. Hungarian space activities were based entirely on international co-operation, in which the Intercosmos programme played a fundamental and decisive role. The work Hungary did and the space communication service it operated within the framework of the Intersputnik International Space Communication System are also very important. Close and fruitful co-operation has developed between Hungary and the Soviet Union and other countries within the Intercosmos programme.

33. In the course of devising instruments for the different space probes, Hungary has developed close links with researchers from Austria, France, the Federal Republic of Germany and the United States of America. Its relations with the ESA and NASA have widened. With a view to the mutual advantages, Hungary's aim is to further develop fruitful co-operation with other national and international organizations.

34. To the best of its ability Hungary does participate in the work of the specialized committees of the United Nations. Its representatives are members of COSPAR and the IAF Bureau, and we regularly participate in and give lectures at the meetings of these organizations. Several Hungarian scientists are members of the International Astronautical Academy (IAA).

SYRIAN ARAB REPUBLIC

[Original: Arabic]

The following information is based on the plans and expectations of the State Organization for Remote Sensing in promoting local programmes for the peaceful uses of outer space and the use of remote-sensing applications in a number of fields, including agriculture, geology, hydrology and the mitigation of natural disasters and pollution, etc.

The State Organization for Remote Sensing, which was established in the Syrian Arab Republic in 1986 as a local and regional centre providing scientific, training and application services to all activities relating to remote-sensing applications, began its work with modest expertise and equipment. It has nevertheless made great efforts to develop its technical and scientific staff and has joined with many scientific institutions in the country in conducting studies of development projects using remote-sensing techniques. The Government of the country has, moreover, accorded special importance to the remote-sensing sector with a view to its playing a full role in all fields of application, particularly agriculture, geology, hydrology, pollution control and the mitigation of natural disasters.

Accordingly, the Organization has drawn up a national plan for the promotion of local programmes using remote-sensing techniques by which it will:

1. Participate in the implementation of practically oriented development projects by producing agricultural studies on such topics as soil classification, land use, the survey and classification of forests and growth monitoring.

2. Participate in the implementation of practically oriented water development projects in the Yarmuk basin area and the Tadmur range and studies of the Barda basin, the A'waj and the Syrian Baqi'ah area.

3. Participate in the implementation of projected geological studies in order to detect the presence of raw materials (minerals and oil) and update the geological maps of the country for the coastal region, the Tadmur region and the southern volcanic region.

4. Participate in the implementation of projected environmental studies for purposes of environmental protection and the prevention of air and soil pollution, particularly in the coastal and central regions of the country.

5. Participate in a number of studies on projecting the occurrence of natural disasters such as earthquakes, storms and floods so as to reduce their hazardous effects.

6. Develop technical and scientific staff by endeavouring to provide short-, medium- and long-term training courses in the field of remote-sensing applications to those topics mentioned above and securing grants and fellowships accorded by States through the United Nations.

7. Develop domestic educational capabilities in the field of the peaceful uses of outer space and remote sensing. For that purpose, the Organization will endeavour to be the hosting institution for a multi-year integrated training programme accepting trainees in the field of remote sensing from all the Arab countries and other developing countries. This is appropriate given that the premises of the Organization, which are situated 18 kilometres north-west of Damascus, were originally designed for the reception of trainees and experts and are provided with classrooms, lecture rooms and all of the equipment required for the conduct of regional training courses. In the event of financial support becoming available for ongoing training courses, the Organization will participate actively in the

development of technical capabilities in the field of remote sensing in the developing countries.

8. Endeavour to hold an international seminar on the importance of remote sensing for the development of local programmes in the developing countries in co-operation with the Committee on the Peaceful Uses of Outer Space and its sub-committees. The Organization is prepared to host such a seminar, make all of the administrative arrangements and provide the premises, possibly in the second half of this year.

9. Participate in the International Decade for Natural Disaster Reduction through the Economic and Social Council of the United Nations.

10. Endeavour to improve technical plant, including technical equipment and laboratories for the processing of space information, so as to be a local and regional focal point and a place where effective co-operation with the developing countries can be achieved under the auspices of the United Nations (committees concerned with the uses of space and with remote sensing).

11. Solicit, from the Committee on the Peaceful Uses of Outer Space, the dispatch of technical advisory services missions from the specialized agencies of the United Nations and increased financial and technical support for the Syrian Arab Republic in the field of remote sensing in order to strengthen that sector in the implementation of development projects.

12. Endeavour to solicit financing from the United Nations Development Programme allocations for the promotion of national and regional activities in the field of remote sensing in the Syrian Arab Republic on the basis of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space regarding the establishment and strengthening of regional mechanisms of co-operation and their promotion and creation through the United Nations system. Accordingly, the Organization will request the United Nations, through the Ministry of Foreign Affairs, to invite a group of United Nations experts to visit the headquarters of the Organization and complete the necessary study for the establishment and strengthening of mechanisms of regional co-operation and their promotion and creation through the United Nations system.

13. Solicit the United Nations to provide opportunities for those working in the remote-sensing sector in the Organization to participate in international seminars and conferences relating to remote-sensing applications and information systems.

14. Solicit from the Scientific and Technical Sub-Committee of the Committee on the Peaceful Uses of Outer Space the involvement of the Syrian Arab Republic in the international geosphere-biosphere programmme for the 1990s, in accordance with the recommendation of the Sub-Committee at its twenty-sixth session that there is a need to involve as many nations as possible in the scientific activities of the programme, both developed and developing countries.

UNION OF SOVIET SOCIALIST REPUBLICS

[Original: Russian]

OUTER SPACE RESEARCH IN THE USSR IN 1989

I. Manned flights

Space transport systems were used in the Soviet Union in 1989 in accordance with the goals set for the achievement of the national programme for the exploration and conquest of outer space and in the context of the programme of international co-operation.

During the past year, the USSR launched 95 space objects of various descriptions.

These space objects were launched aboard 74 carrier rockets of the Soyuz, Proton, Cosmos, Tsiklon and Molniya types. In five Cosmos-series launches, a single rocket was used to put several satellites into orbit simultaneously: three on 10 January (Cosmos-1987 to Cosmos-1989); six on 10 February (Cosmos-1994 to Cosmos-1999); eight on 24 March (Cosmos-2008 to Cosmos-2015); three on 31 May (Cosmos-2022 to Cosmos-2024); and six on 14 September (Cosmos-2038 to Cosmos-2043).

In February 1989, Soviet outer space exploration celebrated the third anniversary of the launch into circumterrestrial orbit and the entry into operation of the Mir scientific research manned orbital complex.

During the three-year period, approximately 5,000 sessions of various research projects were carried out on board the station using over 60 types of research apparatus and equipment with a total mass of 9,000 kg, and some hundreds of kilograms of material with the results of the research were transmitted to Earth. Nineteen cosmonauts worked on board the station.

Since April 1989, following the completion of the planned work on board the Mir-Kvant scientific research complex by cosmonauts A. Volkov, S. Krikalev and V. Polyakov, and their return to Earth, a programme of further research in the complex was conducted under automatic control.

On 6 September 1989, the crew of the fifth basic expedition - A. S. Viktorenko and A. A. Serebrov - was launched. The Soyuz TM-8 piloted by them docked with the Mir orbital complex on the Kvant astrophysical module side on 8 September 1989.

On 8 December 1989, using a mechanical manipulator, a redocking was effected for the first time in the world when the Kvant-2 module, with a mass of approximately 20 tons, was redocked from the axial to the lateral docking facility of the transit module of the station. The redocking took one hour. The service module is a specialized spacecraft designed to provide the Mir manned orbital complex with scientific instruments and equipment and for the conduct of various research projects and experiments in orbit.

The payload delivered by the module in orbit - approximately 7 tons - is designed to ensure the long-term functioning not only of the module itself but of the whole orbital complex.

The module will complement the control system and the system for providing the Mir orbital complex with new equipment.

During the flight, the cosmonauts carried out a wide range of geophysical and astrophysical research projects and technological and technical experiments, including the following:

- Exploration of the central part of our Galaxy in the X-ray band (Roentgen project);

- Mapping of the stellar sky in the ultraviolet part of the spectrum with the aid of the Glazar telescope;

- Experiments with the aid of the Maria spectrometer aimed, inter alia, at measuring fluxes of particles coming from outer space in circumterrestrial space and determining their relationship to seismic activity on the planet;

- Experiments using the Gallar apparatus with a view to producing semi-conductor materials with better characteristics in conditions of microgravity;

- A cycle of measurements of spectral characteristics of the Earth's atmosphere, in particular, of the ozone layer in the tropical zone (Soviet-Cuban project Atlantika-89);

- Photographic surveys and visual observation of biospheric reserves in various regions of the planet (UNESCO Man and Biosphere Programme).

As of 31 December 1989, the Mir orbital station was manned for 995 days out of its 1,408 days' flight time. During this period a total of 30 space objects docked with the Mir station: nine Soyuz-TM transport vehicles (eight with a crew on board and one unmanned); 19 Progress and Progress-M unmanned cargo vehicles; and two Kvant modules. During 1989, 11,124 kg of cargo was delivered to the Mir orbital complex.

In 1990, in order to ensure the uninterrupted operation of the Mir orbital complex as a manned station, the following launches are planned:

- Three Soyuz-TM manned craft (in February, July and November/December);

- The Kvant-3 technological module (in March/April);

- Five Progress-M unmanned cargo vehicles (in March, May, August, September and December).

On 30 July 1989, the two-year space flight of Cosmos-1870 was completed; it had been put into circumterrestrial orbit by a Proton rocket on 25 July 1987. Its

flight programme included remote sensing of the Earth, with the aid of the first Soviet high-resolution radar, around the clock and in any weather. During the satellite's operation, a large volume of radar images of the natural formations of the Earth and of certain regions of the oceans and seas was received. The project confirmed the technical characteristics and high operational qualities of the satellite as a universal space platform for the placement of scientific apparatus with a mass of up to four tons on which space instruments of various kinds could be set up. Research materials were transmitted to the Priroda State Research Centre of the Central Department of Geodesy and Cartography of the USSR, the Institute for Space Research of the Academy of Sciences of the USSR and the Institute of Radio Engineering and Electronics of the Academy of Sciences of the USSR, and to experts in the United States, Finland, France and Sweden.

At present the satellite radio-navigation system Tsikada is being operated within the national economy of the USSR. It can serve an unlimited number of users (naval vessels) and operates around the globe.

The entry into operation of the Global Navigational Satellite System (GLONASS) will make it possible to perfect further the characteristics of the Soviet satellite navigational system. It will permit the global and uninterrupted determination of the co-ordinates and speed not only of ships but also of civilian aircraft.

In order to meet the need for the highly accurate determination of the co-ordinates of various points and space objects in a single geocentric system and to carry out geodesic and geophysical research, Etalon satellites (Cosmos-1989 and Cosmos-2124) were launched in the Soviet Union on 10 January and 31 May 1989. Each satellite consists of a spherical light-reflecting system which, whatever the angular position in orbit, reflects towards the transmitter virtually all the light hitting the satellite from laser beams, enabling remote measurements to be made by ground stations.

The establishment and development of space technology in the USSR provides a very powerful stimulus for the accelerated development of various branches of science and for the technological advancement of the country as a whole. Many examples could be cited of the applications of space research to our national economy. To take only one recent example, mention could be made of the establishment of the Energia-Buran system.

In all, approximately 600 projects were carried out in this area and were recommended for introduction into various branches of the national economy.

During 1989, the Soviet Union continued to co-operate in the exploration and peaceful uses of outer space with the countries participating in the Intercosmos programme in such areas as space physics, space meteorology, space communications, the remote sensing of the Earth, space biology and medicine, and space technology.

A number of international projects (Phobos, Aktivny, Granat and others) were carried with the active participation of various countries.

Work on the Phobos project, which was designed to study the planet Mars and its moon Phobos, the Sun and interplanetary space, was carried out from July 1988

to April 1989. Along with Soviet scientists, experts from Austria, Bulgaria, Czechoslovakia, Finland, France, the German Democratic Republic, the Federal Republic of Germany, Hungary, Ireland, Poland, Sweden, Switzerland and the European Space Agency participated in the preparation of the scientific programme for the project and in putting together the complete package of scientific apparatus and equipment.

Because of the loss of the spacecraft Phobos in the final stage it did not prove possible to complete the project fully. However, scientists and experts from the USSR and from the countries participating in the project believe that only one quarter of the programme was not completed. They point to the scientific value of the large volume of data received during the execution of the project. Thus, during the flight of Phobos-1, unique information was received about the structure and dynamics of the active areas of the Sun. During the flight of Phobos-2, the Phobos orbit was calculated accurately to within 2 to 3 km and a methodology was devised for using television apparatus to measure the trajectory. Also encouraging for science are the results of experiments to measure the magnetic field of Mars and its rarefied atmosphere and the unstable and weak radiation belts of the planet. These measurements, which have aroused universal interest, were carried out with the aid of a thermal scanner with which it was possible to obtain a thermal map of certain regions of Mars. This will help to form an idea not only of the tectonic and volcanic characteristics of the planet but also of the properties of the particles on its surface.

On 15 September 1989, the Cosmos-2044 biosatellite was launched, carrying various biological specimens, including two monkeys, for a 14-day space flight. During the flight, a broadly based research programme was carried out into the mechanisms of the biological effects of weightlessness with a view to gaining a fuller understanding of the pattern of adaptation of an organism to weightlessness.

Scientists from Canada, Czechoslovakia, France, the German Democratic Republic, Hungary, Poland, Romania, the United States, and the European Space Agency took part in the flight programme.

In order to obtain meteorological data in the visible and infra-red ranges of the spectrum, a proposal has been made to launch a geostationary satellite with television equipment. Its specifications will make it compatible with the international system for geostationary weather satellites, used by Western European countries, the United States and Japan. The programme for improving existing weather satellites includes measures to prolong their active life in orbit.

The USSR is further expanding its commercial activities in outer space. For launching satellites, automatic and manned spacecraft to conduct research and experiments, technological units (the Zona and Splav electric furnaces) for producing semi-conductor materials, and the Kashtan unit for the separation and purification of biological substances, Glavkosmos USSR makes available, on a commercial basis, its launch vehicles of varying capacities of the Proton, Soyuz, Molnia, Vostok and Tsiklon types, whose specifications have already been provided in the proposals made by Glavkosmos USSR for their commercial use.

In addition, the USSR has developed the new highly automated universal Zenit multi-purpose space rocket system. The Zenit launch vehicle consists of two stages, uses ecologically clean fuel components (paraffin and oxygen) and can put payloads of up to 12 tons into orbit.

This launch vehicle can be recommended for commercial use in launches from the Baikonur Cosmodrome.

Glavkosmos USSR offers non-Soviet citizens the opportunity to carry out space flights on the Mir orbital station, on a commercial basis.

In October 1989, representatives of the Japanese television broadcasting corporation TBS began training at the Y. A. Gagarin Cosmonaut Training Centre. Citizens of Austria and the United Kingdom have been in training at the Centre since January 1990. Flights with a Japanese, an Austrian and an English cosmonaut on board are scheduled for 1991.

II. Programmes for the application of space technology

1. In 1989, the USSR continued to work on the use of space technology for hydrometeorology and natural resources exploration. To fill a gap in the existing space meteorological system, it launched a Meteor-2 satellite on 28 February 1989 to gather global weather information in the visible and infra-red ranges of the spectrum and measure radiation levels in circumterrestrial space, transmitting this information to receiving facilities in the USSR and foreign countries.

On 25 October 1989, it launched Meteor-3 whose main purpose is to upgrade the space meteorological system by, among other things, testing new data-measurement equipment and remote-sensing methods. The satellite carries equipment similar to that on Meteor-2, but with improved spectral, radiometric and geometric characteristics.

Information from the Meteor-2 and Meteor-3 satellites is relayed to the main and regional processing centres of the USSR State Committee on Hydrometeorology and to automatic receiving stations; the information is transmitted for use by regional and local weather-forecasting centres and is also distributed through communications channels to other users, including meteorological centres in a number of countries.

In space meteorology and oceanography, research continued on the collection, analysis and use of satellite hydrometeorological information for the purpose of providing data to various branches of the national economy and improving weather forecasting. Satellite data were used in large-scale weather and forecasting charts, incorporated on an experimental basis in regional (meso-scale) short-term weather forecasting charts, and used in climatological research and the monitoring of climatic parameters.

Improvements were made on the global operational system for the thermal sounding of the atmosphere using measurement data from the Meteor satellite, work was carried out on the establishment of a regional sounding system using NOAA satellite data. Work continued on methods of using measurement data received from weather satellites for evaluating the components of the radiation balance in the upper atmosphere and on the Earth's surface.

A system for the effective monitoring of sea-ice cover with an extensive network of subscribers was established and is being operated on an experimental basis. The system is based on existing observation and communications satellites. The algorithms and programmes which have been developed make it possible to analyse and process raw data in an interactive mode.

The monograph entitled "Radiolocation of positions on the Earth's surface from outer space", which summarizes the scientific data obtained from the side-looking radar satellite (Cosmos-1500), has been prepared for publication.

Theoretical and experimental research on the artificial modification of the ionosphere in active experiments was conducted. Studies were made of the particularities of aeronomic and plasma processes in local and non-local disturbances in the middle-latitude and auroral regions of the ionosphere in the development of plasma phenomena. The principles of the theory and numerical models of the triggering events were developed through the conduct of active experiments in the equatorial ionosphere.

In two expeditions on the research vessel Professor Zubov, new data on the nature of the distribution of atmospheric temperature and density in the North Atlantic at altitudes of 30 to 80 km were obtained by the Lidar sensing method; in the Bay of Biscay, the parameters of atmospheric gravitation waves were studied in conjunction with simultaneous Lidar sensing in French territory.

By analysis of the nature of solar proton events observed by the Meteor satellite during the growth phase of solar activity in the twenty-second cycle, a statistical model was made of the radiation properties of solar proton events in the form of a probability distribution of the number of solar proton events by radiation properties; an empirical model was also developed in the form of the analytical dependence of the temporal and spectral characteristics of solar proton events on the length of the solar flare, taking into account the coronal distribution of protons.

A simple universal analytical model of the effects of galactic cosmic rays in circumterrestrial space, indicating the latitudinal distribution of particle streams, including the effects of the generation of secondary particles, was developed.

Comprehensive research conducted on Kheys Island (Franz Josef Land) in the winter of 1989 yielded data indicating that, despite the presence of physical conditions conducive to the develcpment of heterogeneous chemical processes, there is no ozone depletion in the northern hemisphere during spring months.

An analysis of the results of a comprehensive experiment conducted in 1989 at the Molodezh and Mirny observatories (Antarctica) showed that, in the Antarctic spring of 1989, there had been a decline in ozone at altitudes of 15 to 20 km; however, the decline was not as intensive as in 1987.

As a result of a four-year cycle of measuring ozone concentrations using the SFM-1 UV absorption spectrometer-ozonometer installed on a Soviet weather satellite, a preliminary model of the vertical ozone distribution over Antarctica in the altitude range of 50 to 80 km was constructed, and the amplitude of annual variations was determined. Maximum concentrations of ozone were observed during the summer period while minimum concentrations were recorded for the winter period.

It was decided to install the American TOMS apparatus, used to measure overall ozone content, on the Meteor satellite.

2. Through the All-Union association Morsvyazsputnik, co-operation between the USSR, the United States, Canada and France in the peaceful use of outer space continued in the joint use and operation of the international search-and-rescue satellite system for ships and aircraft in distress (Cospas-Sarsat). On 4 July 1989, the USSR launched the Nadezhda satellite as part of that system.

The organizational framework of the system has been completed, and the founding countries (USSR, United States, Canada and France) established the Cospas-Sarsat Council and its secretariat, which carries out administrative functions. Matters relating to the operation of the system and interaction within it, as well as prospects for developing and carrying out the Cospas-Sarsat programme, are considered at meetings of the Council and working groups, at which both the founders of the system and representatives of countries which have joined the programme take part.

Currently, in accordance with the intergovernmental agreement between the USSR, the United States, Canada and France, signed on 1 July 1988, the co-ordinating and computing centres of the founding countries, the United Kingdom, Norway and India, operate around the clock, as do 18 data-receiving stations situated in many countries including, in addition to those already mentioned, Italy, Australia and Brazil. There is close technical and operational interaction among all co-ordinating and computing centres of the Cospas-Sarsat system.

The number of users of the Cospas-Sarsat system has increased significantly and currently amounts to about 20 countries. The joint use of the system by the agencies and organizations of many countries in conducting search-and-rescue operations saved about 1,500 human lives between 1982 and 1989.

In the implementation of the international Cospas-Sarsat programme, much attention is being devoted to the further development of the system and the improvement of its technical means, including the broadening of its capacity, the use of geostationary satellites for improving the efficiency in providing notification about disasters, and the enlargement of the number of potential users of the system. The scientific, technical and operational co-operation among organizations and agencies in diverse countries under the Cospas-Sarsat programme is marked by a constructive approach and mutual understanding.

The Soviet Union is a member of the International Maritime Satellite Organization (Inmarsat). The All-Union association Morsvyazsputnik is a party to the Inmarsat Operational Agreement and operates the space segment of Inmarsat through its coastal land-based space-communications centres situated at Odessa and Nakhodka. These centres offer satellite-communications services to ships of all nationalities equipped with on-board satellite-communications stations. More than 600 vessels of the Soviet fleet are currently equipped with such stations.

Within Inmarsat, the USSR is co-operating in the development and introduction of new and more effective means of satellite communication with moving objects, including aircraft and various forms of land transport. The USSR is participating within the framework of Inmarsat in developing the specifications for the third generation of Inmarsat satellites and in financing their manufacture, and also intends to take part in the tendering for the manufacture and launch of these satellites.

3. The development of space travel in the USSR has opened up new perspectives in the study of the environment and natural resources. Space technology affords a large amount of information about the Earth and efficiency in providing it. More than 300,000 photographs of the Earth's surface have been taken by the automatic resource-surveying equipment of the Resurs system and from manned orbital stations. Practically the entire territory of the USSR, as well as 30 per cent of foreign territory, has received coverage under the surveys conducted by spacecraft of the Resurs system. Many regions have been covered more than once.

The photographs, especially those produced by the second-generation Resurs system, are superior in geometric properties and resolution to those produced by the American Landsat and French SPOT systems. The Resurs system has on-board capability for photography in four bands of the electromagnetic radiation spectrum, and the images are distinguished by their high information content and ground resolution and their good geometric characteristics.

The imagery generated by the Resurs system is used for the effective and reliable solution of problems connected with the comprehensive inventorying of Earth's national resources, including land, forest and fodder-crop stocks, in assessing their state and dynamics, in prospecting for minerals such as oil, gas and potable ground water, in assessing and forecasting environmental conditions, in studying and mapping the shelf, in assessing the danger of mudflows and landslides, in producing and updating topographical maps, etc.

The simultaneous coverage of large territories by space surveys affords the possibility of obtaining a better picture of natural processes in their multiplicity and their dynamic aspect, and of conducting comprehensive, interrelated studies, covering a specific period, of large groups of natural resources.

The space survey materials undergo initial interdisciplinary processing, and are then distributed to interested organizations.

Space imagery is currently used by more than a thousand scientific and production organizations in 22 branches of the Soviet economy, and also by other countries.

The Central Department of Geodesy and Cartography of the USSR (GUGK) produces for organizations in the USSR and foreign countries about a million units of various types of photographic information. Original and enlarged black and white, colour, single-band and multiband photographs, double negatives and positives, synthesized imagery, photographic plans, photographic maps on various scales and other items are produced.

GUGK has conducted jointly with the USSR Academy of Sciences, using both its own manpower and that of a large number of sectoral scientific and production organizations, comprehensive study and mapping based on space information of the natural resources of Tadzhikistan, Uzebekistan, Kirghizia, Kalmykia, Stavropol, the Kalinin district and other territories.

The work done has permitted more rational solution of problems relating to natural resource utilization, conservation and regeneration, prospecting for minerals and comprehensive assessment and forecasting of environmental conditions.

Photographs taken from space are being used to produce topographical maps of Antarctica on various scales.

The achievements of the USSR in the field of remote sensing for peaceful purposes have permitted the broad development of mutually advantageous international co-operation.

GUGK, as part of its contribution to the development of co-operation with foreign countries in the peaceful utilization of outer space, has concluded with foreign firms and organizations in various parts of the world, through the foreign trade organization Soyuzkarta, a number of long-term contracts and agreements for the delivery of space photographic materials.

GUGK conducts this activity on the basis of respect for the principle of full and permanent sovereignty of the States surveyed, as reflected in the resolution adopted in December 1986 at the forty-first session of the United Nations General Assembly.

At present Soyuzkarta is making deliveries of space photographic products to countries in North, Central and South America on the basis of long-term agency agreements with the firms Contitrade in the United States of America, Interar in Argentina, Aerosul in Brazil, Cartfoto in Peru and Imexia in Cuba. Deliveries of photographic products are successfully being made to Japan, Syria, China, the Yemen Arab Republic, Australia, France and Afghanistan. Photographic products are also supplied in response to requests by the United Nations, and particularly by FAO. Talks are under way with firms in New Zealand, Malaysia, the United Kingdom, Belgium, Iraq, Egypt and other countries on the delivery of space products under long-term agreements.

Surveys of foreign countries from space by Cosmos-series spacecraft and manned orbital stations are generally conducted on application from the collaborating countries.

The Soviet space photographic information bought by foreign firms and organizations is successfully used by them for producing and updating topographic maps, producing thematic maps, prospecting for minerals, studying relief and marine and ocean currents and investigating the dynamics of natural resources for purposes of monitoring and protecting the environment.

When space survey materials are received, the necessary information is sent to the clients.

Charts and outline maps indicating the availability of imagery, contact prints from original negatives, examples of space products, catalogues, perspectives and so forth are produced and sent abroad as publicity and promotional material.

To enable organizations to make more effective use of space imagery, GUGK offers advisory services and practical training for foreign specialists in a variety of subject areas. Scientists and highly skilled experts are brought in for the training courses.

In October 1989, GUGK experts took part in an international meeting of an expert group on detection of illegal planting of narcotic crops by means of remote sensing.

The meeting was held at the Vienna International Centre under the auspices of the United Nations Division of Narcotic Drugs. At the request of the Division, documents were submitted at the meeting prepared on the basis of high-resolution space imagery covering individual regions of the world. Some of these materials were acquired by the Division of Narcotic Drugs for use in its work.

A considerable part of the Soviet Union's remote-sensing activity involves the conduct of experiments on board the Mir orbital station during joint space flights by international crews, and processing of their results.

In 1989, experts from the Soviet Union and Syria completed work on the processing of the results of the Efrat remote-sensing experiments conducted during the flight by the Soviet-Syrian crew. A joint summary scientific and technical report on the results was published.

Soviet and Bulgarian experts have completed their joint work on the analysis, processing and utilization of materials from the photographic, spectrometric and colorimetric surveys carried out using KATE-140, Spektr-256 and Tsvet-1A equipment during the flight by the crew which included the second Bulgarian astronaut.

In the course of 1989 a number of technical meetings between experts from the USSR and Afghanistan took place at which work was conducted on the thematic processing of materials from the space surveys conducted during the Soviet-Afghan flight.

The materials and results of the remote-sensing experiments conducted by the international crews are widely used in many organizations and enterprises in the countries which participated in these flights for purposes of earth sciences and in the interest of developing their national economies.

4. In 1989 the USSR continued the further development and improvement of its communications and broadcasting facilities using satellite systems to meet the demand for various communications services: radio, television, telephone and telegraph links and transmission of data and facsimile information.

To develop the multiband satellite television system in the USSR, a new generation of direct television broadcasting satellites (Statsionar-T2) has been developed. The new satellites are equipped with double transponders which permit transmission of television signals over two frequency channels in the 0.7 GHz frequency band. The system using the satellites has been named Ekran-M.

Work is also continuing on the national direct television satellite broadcasting system in the 12 GHz frequency band. The launch of the first satellite and the commencement of experimental transmissions in the 12 GHz range are scheduled for 1992. With this system, it will be possible to organize transmission of the Republics' television and stereo sound programmes.

In order to enable Soviet citizens working abroad in Soviet embassies to receive Central Television programmes, a system is in operation for transmitting TV programmes over the Moskva-Global'naya station network. At present, more than 30 receiver stations are operating in the network with 3-4 m antennas in the 4 GHz frequency band.

Apart from TV programmes, the Moskva satellite system also transmits radio broadcasts and newspaper page impressions. To receive the page impression signals, Moskva stations are installed at printing works. Currently, page impressions are received through these stations in 30 Soviet towns.

Development of the system for discrete improved-quality transmission of sound broadcasts (the Orbita-RV system) has continued. This system transmits simultaneously 25 sound broadcast programmes and page impression signals. In 1989, there were 18 ground stations in the Orbita-RV system.

Work is continuing on the establishment of national satellite systems for television broadcasting in the 14/11 GHz frequency range, based on the Luch satellite. The ground stations used to receive the signals are fairly simple and inexpensive, with 4 m diameter antennas.

Work has begun on the development of a future satellite communications and broadcasting system which will include multichannel multipurpose satellites. To place these satellites in orbit, it is planned to use Energiya and Proton-M launch vehicles.

With a view to improving the operation of telephone channels and increasing their carrying capacity, new types of equipment have been developed for Earth stations, including the MDR-60 with a digital throughput rate of 60 mbit/sec, capable of handling up to 1,728 simplex telephone channels with a 36 MHz bandwidth and designed to operate both through existing Gorizont satellites and through future satellites.

Work is being conducted on the development of a special business communications network using ground stations with small parabolic antennas 2.5-4 m in diameter.

The Soviet Union's international activity in space communications and broadcasting has covered a number of aspects.

The Soviet Union has continued to work actively in the Intercosmos programme:

- In 1989 work continued on the further development and improvement of the Dubna-Intercosmos International Experimental Satellite Communications Centre. Preparation was completed of the technical facilities for conducting an experiment to study ground-to-satellite wave propagation in the 11/20/30 GHz frequency bands;

- A digital channel-forming device (the DKD-400) has been developed which allows a satellite transponder to handle, on the single channel per carrier principle, 400 voice circuits or 800 data transmission links. The use of effective methods of converting voice signals into digital form, at a rate of 32 kbit/sec, and of interference-resistant transmission methods, enables ground stations to work with small-diameter antennas (3-4 m in the 4/6 GHz range and 1.2-2 m in the 11/14 GHz range) using a low-powered transmitter (4-6 W per circuit);

- A specialized small ground station has been developed for the operation of a computer network in the banking operations system;

- A large amount of theoretical research has been carried out: methods have been developed for constructing synchronization systems in future MDVR-equipped satellite systems using on-board multibeam antennas; possibilities for transmitting radio signals in digital form jointly with television signals in the 12 GHz range and analog-digital methods of transmitting improved quality and high-definition television signals together with their soundtrack.

A program has been developed, using computers, for solving the problem of electromagnetic compatibility of satellite systems, and the program for selecting satellite positions in the geostationary orbit has been improved.

Equipment has been developed in the USSR to compensate for the interference between satellites in the geostationary orbit.

In 1989 experts from the Soviet Ministry of Communications participated in various co-ordination meetings on co-operation and the Intercosmos programme.

The Soviet Union is a member of the international space communications organization Intersputnik, and is actively working to increase the effectiveness of its activities.

Intersputnik is leasing from the USSR transponders on Gorizont satellites (international designations Statsionar-4 and Statsionar-13) for the exchange of television programmes and the transmission of telephone calls and other information using the ground stations of the Intersputnik system. Intersputnik ground stations, the technical equipment for which was developed largely in the USSR, have now been installed in 18 countries (in the Indian and Atlantic Ocean regions). During 1989, Soviet experts continued work on the modernization of the Intersputnik ground stations in Poland and the German Democratic Republic. Equipment was manufactured and delivered to Czechoslovakia for the construction of a second Intersputnik ground station.

The development of a new generation of equipment for the Intersputnik ground stations was completed. The equipment is based on new advanced radio components. It is more reliable, lighter and smaller, consumes less energy and has more up-to-date ergonomic properties.

In 1989, specialists from the USSR Ministry of Communications participated in the work of the conference of experts to develop the Intersputnik system and the session of the Intersputnik Council in the discussion concerning the "Intersputnik Development Programme Up To The Year 2000".

As a member of the International Telecommunication Union (ITU), the Soviet Union actively participated in the work of the Study Groups of the International Radio Consultative Committee (CCIR), which is a permanent body of ITU. Taking part in the work of the Groups' final meetings on questions relating to satellite communications, experts from the USSR Ministry of Communications have made significant contributions with regard to issues concerning fixed satellite service, joint use of frequencies and co-ordination between fixed satellite service and radio-relay systems, radio-broadcasting satellite service, and effective use of the radio-frequency spectrum and the geostationary orbit. The Soviet contributions relating to these questions will be reflected in the reports and recommendations of CCIR.

In 1989, representatives of the USSR Communications Administration held eight meetings with representatives of the communications authorities of Belgium, Canada, Italy, Papua New Guinea, the United Kingdom and the United States and of Intelsat and Inmarsat to co-ordinate frequency assignments in satellite communication networks. Fifty Soviet satellite networks are currently registered with the International Radio Frequency Registration Board.

III. Scientific programmes for the investigation of outer space

1. Experiments were continued in 1989 at the Roentgen observatory, which is part of the Kvant orbital module docked with Mir. Its scientific payload includes:

- An X-ray telescope with aperture mask;

- A high-energy scintillation X-ray telescope;

- A gas scintillation spectrometer;

- A Pulsar X-1 hard X-ray telescope and spectrometer.

The gross weight of the observatory is 1,000 kg. It has a power consumption of roughly 350 W, and a data output of up to 50,010 bits per 24-hour period. In 1989, the Roentgen observatory was used for 1,000 observation sessions to investigate various X-ray sources.

The most important results so far are:

- The discovery of hard X-ray radiation from supernova SN 1987 A in the Large Magellanic Cloud;

- Mapping of the Large Magellanic Cloud and the central region of the galaxy;

- Discovery of a number of new transient sources.

2. The Granat international space observatory was put into orbit on 1 December 1989. The Granat satellite is designed to investigate bright sources in the hard X-ray and gamma ranges. In eight months of work with the satellites, it is expected that detailed investigations of up to 100 of the most interesting celestial gamma sources will be conducted.

The project's scientific apparatus includes Soviet ART-P and ART-S telescopes and the very large French Sigma telescope, which has the capability to construct gamma-images of selected segments of the sky. The energy range of the three telescopes is from 4 to 1,300 keV. The satellite is also equipped with 4 Danish Watch detectors and 6 French Phébus gamma-burst detectors. The Sigma telescope is equipped with French star detectors, an on-board computer and a 128-megabit bubble memory, which is used, inter alia, to service the Soviet ART-P and ART-S telescopes.

Tests were conducted of all the satellite systems and scientific instruments and indicated that the entire on-board apparatus was operational.

3. The international Aktivny project is being implemented by Soviet experts jointly with experts from Bulgaria, Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Poland and Romania under the Intercosmos programme, with organizations and experts from Brazil, Canada, Finland, Japan, New Zealand and the United States participating in the implementation of the scientific programme.

The main aim of the Aktivny project is research on the distribution of electromagnetic waves in the very low frequency range in the Earth's magnetosphere, as well as their interaction with energetic charged particles in the radiation belts, using a space-based plasma-physics laboratory on board an AUOS-3 spacecraft (active and diagnostic apparatus) and a Czechoslovak S2-AK subsatellite which is manoeuvrable in space (diagnostic apparatus).

In conducting the scientific programme, ground installations, including observatories abroad, will be used and experiments correlated with measurements made by spacecraft of other countries - the United States and Japan - will be carried out.

On 29 September 1989, the Soviet Tsiklon carrier rocket was launched and the Intercosmos-24 spacecraft was put into its assigned orbit with a high degree of accuracy.

The separation of the Czechoslovak S2-AK subsatellite was carried out and it is being tracked and controlled by Czechoslovak specialists at the ground station in Panska Ves (Czechoslovakia).

The single SRA-20 antenna was deployed and configured.

All the diagnostic instruments on board the basic apparatus indicated that the main modes were fully operational.

The first phase of the scientific programme was completed at the end of 1989.

Scientific research is continuing at the present time.

The following work was carried out in 1989 with regard to future scientific projects within the framework of international co-operation:

- The gamma telescope "Gamma-1" designed for extra-atmospheric gamma-ray-astronomy observations in the 50-5,000 MeV energy range.

Specialists from France, Poland and the USSR are taking part in the project.

In 1989 joint testing was completed of the gamma telescope "Gamma-1", the X-ray telescope Pulsar X-2 - Spektr-2 and the Telezvezda star sensor in a composite test assembly; factory tests were carried out of scientific instruments used on board the flight model of the satellite; the characteristics of the Gamma-1 gamma telescope were determined; software for operational checking of the functioning of scientific instruments in flight and processing the scientific information obtained through them was prepared and debugged; the program for observing astronomical objects was fine-tuned.

The experiment is scheduled for 1990.

- The Relikt-2 project, planned for 1992, will carry out multi-frequency measurements of the anisotropy of background radiation in the 20-200 GHz frequency range.

The study of large-scale fluctuations in the anisotropy of relict radiation caused by gravitational-field variations may be particularly valuable.

Tests of laboratory mock-ups of radiometers together with low-frequency power units were conducted in the past year; laboratory mock-ups of a star sensor and of power supply units for the low-frequency component of a radiometric package were developed.

Experts from Bulgaria, Czechoslovakia, Poland, the Soviet Union and the European Space Agency are participating in the development of the scientific apparatus for the project.

- The Radioastron project consists of a ground-space radio interferometer for astrophysical research. This interferometer is to include a 10-m-diameter space-based radio-telescope on board a Spektr-R spacecraft which will be put into an elliptical orbit with a 24-hour orbital period and an 80,000-km apogee. The Radioastron project is designed to construct high-quality radio-images of astrophysical objects with super-high angular resolution. The project is based on methods using very-long-baseline radiointerferometry.

Radioastronomical observatories and scientific and technical organizations and firms from 13 countries are participating in the preparation of the project and the development of on-board and ground-based scientific equipment.

The breadboarding of most of the on-board scientific instruments was completed towards the end of 1989.

The plan for testing the entire on-board scientific apparatus and preparing ground facilities is designed to ensure that the scientific ground-space complex is ready for the launching of the Spektr-R spacecraft at the end of 1993.

- The Interbol project, whose scheduled launch date is 1992, consists of two satellite pairs. One pair (a satellite and a subsatellite) has an orbit with an apogee of about 20,000 km and traverses the auroral regions of the Earth's magnetosphere. The distance between the spacecraft varies from 100 to 1,000 km. The second pair has an orbit with an apogee of 150,000 km and is scheduled to carry out research into the processes in the tail and edges of the Earth's magnetosphere. The distance between the main satellite and the subsatellite varies from 1,000 to 10,000 km. This configuration of space vehicles enables research to be done both into the global interconnections between phenomena in the solar-terrestrial system and into the ephemeral patterns of phenomena in critical regions of the Earth's magnetosphere.

In 1989 tests continued on scientific instruments and space vehicle systems. Theoretical work was also carried out on the dynamics of charged particles in the complex magnetic geometry which is characteristic of circumterrestrial space, and questions concerning the acceleration and heating of plasma and the collective interaction of particles and waves in a magnetosphere environment were resolved.

Interbol is an international project in which specialists from the USSR, the German Democratic Republic, Czechoslovakia, Bulgaria, Poland, Romania, France, Italy, Sweden, Canada and the European Space Agency are co-operating.

- In 1989 work began on the new research programme in solar-terrestrial physics called the Regata project. The name of the project is related to the particular features of a new type of space vehicle developed at the Institute for Space Research of the USSR Academy of Sciences which is equipped with solar sails that maintain the orientation of the vehicle. The system adopted in such vehicles

(space Regata) will make it possible for highly accurate, detailed measurements to be made, between 1994 and 1998, of plasma and magnetic-field parameters in the Earth's magneto-plasma sheath.

At present optimum orbits are being selected for research into the key physical processes occurring in the Earth's magnetosphere. It would seem advisable to conduct research on equatorial orbits at distances of the order of 20,000 to 30,000 km, where basic interaction takes place between cold and hot plasma, in polar orbits and orbits which are held in the tail of the magnetosphere with the assistance of the gravitational influence of the Moon.

In 1989 work was being done on systems planning for the space vehicle and the scientific apparatus for plasma research and research into electromagnetic fields.

Regata is also an international project. There are plans for participation by specialists from the European Space Agency, the United States, Canada and a number of European countries.

- In 1989 the scientific aims, scenarios and mock-up of the Mars-94 mission were discussed at a number of international meetings. A mock-up has been planned of the scientific apparatus of each element of the mission - the orbiter, the aerostat probe in the atmosphere, the small stations on the surface of Mars and the penetrators. Work has been done on building the scientific apparatus.

Specialists from Austria, Belgium, Bulgaria, Czechoslovakia, Finland, France, the German Democratic Republic, the Federal Republic of Germany, Hungary, Ireland, Italy, Poland, Romania, Sweden, the USSR, the United Kingdom, the United States and the European Space Agency are taking part in the project.

It is scheduled to be implemented in 1994.

- Work has continued on building the Spektr-Roentgen-Gamma international astrophysical observatory. The launching of this observatory is planned for 1993. The technical proposal stage has been completed, and work is being done on making an outline plan.

Taking part in the project alongside Soviet scientists are specialists from Australia, Bulgaria, Canada, Czechoslovakia, Finland, France, the German Democratic Republic, the Federal Republic of Germany, Hungary, Italy, Switzerland, the United Kingdom and the United States.

The mock-up of the scientific apparatus of the project has been completed. It includes:

- A Soviet-Danish X-ray concentrator telescope with a focal length of 8 m and an effective area of 3,500 sq. cm., and which has a sensitivity range of 0.3 to 10 keV and opens out in space;

- A grazing-incidence high-resolution JET-X X-ray telescope (USSR, United Kingdom, Italy, Federal Republic of Germany);

- An X-ray telescope with a MART (USSR) coded aperture for research into the spectra of nuclei of active galaxies and variable X-ray sources in the hard X-ray range;

- A normal-incidence EVVITA telescope for the extreme ultra-violet range (USSR, Switzerland, United Kingdom, German Democratic Republic);

- A wide-angle X-ray ART-SP monitor (USSR);

- An all-sky telescope (USSR, United States);

- SPIN equipment for research into gamma-bursters in outer space (USSR);

- An X-ray polarimeter (United States, USSR, Italy);

- Two detectors for gamma-burster spectroscopy in the 100 keV to 100 MeV range;

- The model of the gamma-burster instrument package also includes a cooled detector of high-purity germanium for high-resolution gamma-burster spectroscopy.

The preparatory, testing and calibration stages for the on-board apparatus begin in 1990.